MgO-Au Cermet Films

SECONDARY EMISSION CHARACTERISTICS UNDER ELECTRON BOMBARDMENT

The production of MgO-Au cermet films by sputtering from pressed composite targets of MgO and Au was first described by V. E. Henrich and J. C. C. Fan of the Lincoln Laboratory of the Massachusetts Institute of Technology in 1972 (1) and 1974 (2). These films are of particular interest from two points of view.

Firstly, they are highly absorbing in the solar spectrum and highly transparent in the infrared, and by depositing them on metal substrates, solar absorbers of high efficiency have been produced, which have the virtue of being stable in air up to 400 °C (3).

Secondly, and by virtue of their MgO content, these cermet films are good secondary emitters of electrons and therefore of interest as materials for secondary emission electrodes. With the exception of some 'negative' electron affinity materials (e.g. cesiated semiconductors), MgO is probably the most efficient secondary electron emitter which is available. Nevertheless it can be applied to secondary emission electrodes only in layers thin enough (< 10 nm) for charge to tunnel from the conducting substrate to neutralise the surface charge produced on its surface by the primary electron beam. Such thin layers have limited lives in high power applications, since MgO is lost from the cathode surface during bombardment as a result of its dissociation and the subsequent evaporation of Mg and O at rates which are related to the primary electron energy, the current density, and the ease with which heat is dissipated.

When the MgO is embedded in a gold matrix, however, the gold provides conducting regions between the small particles of oxide, so that much thicker films can be used. As a result, a practical benefit which might be expected to result from the substitution of MgO-Au for MgO in a secondary emission cathode would be an extended life particularly under conditions of intense bombardment or high temperatures where erosion would be accelerated.

G. F. Dionne and J. F. Fitzgerald, also of the Lincoln Laboratory of the Massachusetts Institute of Technology, have recently reported (4) on a 4 000 hour life test of a 75 MgO/25 Au cermet film as a secondary emission cathode. The film was 50 nm thick and was sputtered on to a stainless steel substrate, and the rate of change and extent of variation in its secondary emission properties were observed under intense (2 keV) electron bombardment. At the same time changes in emission were correlated with compositional differences in the surface layers, as revealed by periodic Auger analyses.

The results indicated that the film was durable and retained good emission properties, the rate of material loss by MgO dissociation and elemental evaporation appeared to be less than 1 Å per 8 hours, so that an operating life for a film of 300 nm thickness under the experimental conditions could be as much as 24 000 hours.

The initial yields, which were double the final (see Figure) and approximated to those from bulk MgO, fell rapidly in the initial stages and this was related to the cleaning of the surface of the cermet by argon ion bombardment before the trial was started. Henrich and Fan (5) have described how this can give rise to differential sputtering of the gold to leave a surface depleted of gold to a significant depth. The Auger analyses confirmed this interpretation. The initial values of the maximum secondary yield (8.4) and crossover energies (16 eV) observed may therefore be regarded as those of almost pure MgO, whereas the final yield values (3.7) and crossover energies (25 eV) may be taken as realistic for the actual bulk 75 MgO/25 Au composite.

These findings should stimulate further interest in these coatings and in gold cermet coatings of other types.

W.S.R.

References

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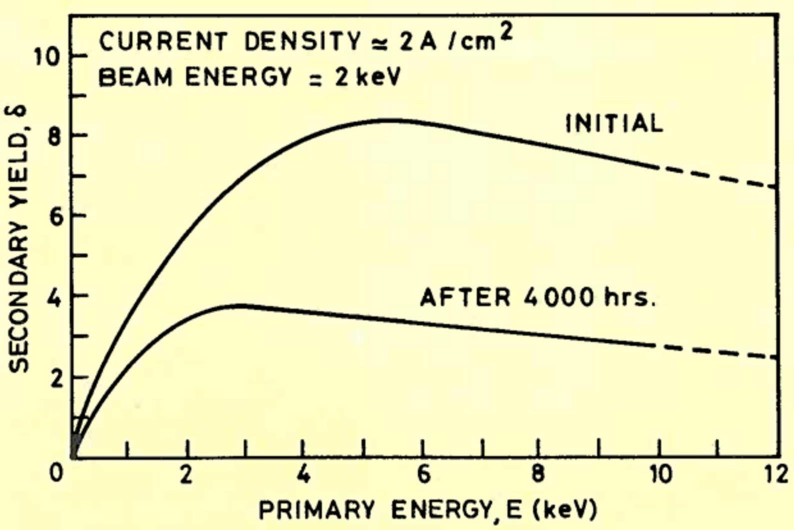

Secondary - electron - emission-yield curves of a MgO/Au-cermet film before and after 4 000 h of electron bombardment at 2 keV beam energy and 2 A/cm² current density. Most of the decrease in secondary yield occurred within the first few hundred hours of testing. (From Dionne and Fitzgerald (4))